The usage of forward models in dynamic landmark navigation: from insects to robotic mapless autonomous navigators

Zenon Mathews[1,2,3], Markus Knaden[4] and Paul Verschure[1,5]

[1] SPECS, Technology Department, University of Pompeu Fabra, Barcelona, Spain

[2] Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan

[3] Japan Society for the Promotion of Science (JSPS), Tokyo, Japan

[4] Max Planck Institute for Chemical Ecology, Jena, Germany

[5] Catalan Institution for Research and Advanced Studies (ICREA), Spain

Autonomous navigation in dynamic worlds requires the acquisition, retention and optimal exploitation of knowledge. There is strong convergence in robotics and neuroscience that vertebrates rely on forward models to achieve behavior optimality. We address here the question whether also insects use forward models to navigate in dynamic environments. We analyze navigational behavior of the *Formica cunicularia* ant species in controlled landmark manipulation experiments. Our analysis shows that ants use expectations about the relative direction and distance of landmarks to generate actions. This confirms that these animals use forward models in order to optimally exploit the environment. Given the small scale of the ant brain, however, the question arises what the minimal model would be that can account for this prediction based navigation. Building on the Distributed Adaptive Control architecture we propose a memory and action selection mechanism to model ant navigational behaviors. Using robots exposed to equivalent tasks we demonstrate that our model accurately captures the behavior of ants. Our model predicts specific insect behaviors in dynamic environments. In order to directly test these predictions we are currently constructing a highly scalable and versatile hybrid insect-robot mixed-reality system that is capable of providing behavior dependent multimodal cues to the insect.